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Effects of selected exotic and native aquatic plant communities on water temperature and dissolved oxygen

by

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Many studies have examined the distribution of aquatic plants in relation to water chemistry parameters or, in essence, the influence of the water environment on growth and metabolism of aquatic plants. Among these are the studies of Moyle (1945), Seddon (1972), Pip (1979), Hellquist (1980), and Kadono (1982). However, fewer studies have examined the influence that aquatic plants exert on their water environment. Plants interact with water through dynamic processes such as chemical uptake and excretion, physical processes such as shading and reduced circulation, and ecosystem processes such as organic matter production and decomposition (Carpenter and Lodge 1986). Perhaps one of the reasons for the relative lack of studies is the difficulty in differentiating between the

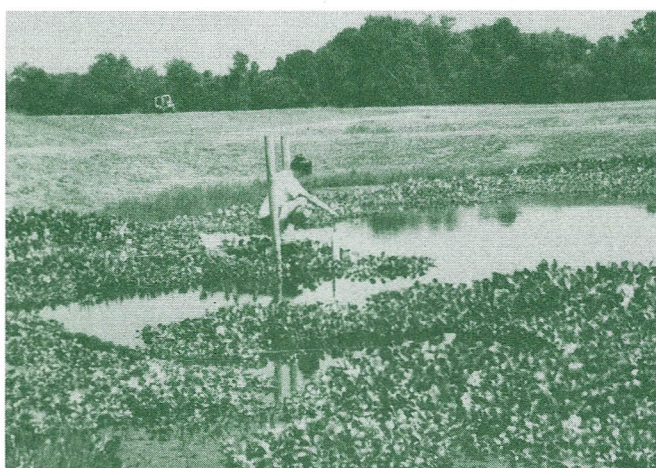
natural geochemical variability among lakes and the biological/chemical effects of aquatic plants on their environment.

The ponds located at the Lewisville Aquatic Ecosystem Research Facility (LAERF) in Lewisville, Texas, provided a unique opportunity to examine the impacts of different aquatic plant species on water chemistry. An earlier study (Honnell, Madsen, and Smart 1992) examined the effect of different aquatic plant species on four specific water quality parameters (temperature, dissolved oxygen (DO), pH, and conductivity) using ponds filled with lake water of initially similar chemistry. That earlier study has since been expanded to include additional water chemistry parameters over an extended period. The information on DO and temperature presented in this article was collected as part of the extended investigation.

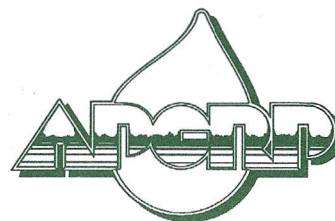
Methods

Study ponds

Vegetation types selected for this study included monocultures of three exotic species, a monoculture of a native species, and a mixed native plant community. The exotics included the free-floating aquatic plant waterhyacinth (*Eichhornia crassipes*) and two submersed species, hydrilla (*Hydrilla verticillata*) and



Deployment of Hydrolab datasonde in a waterhyacinth pond

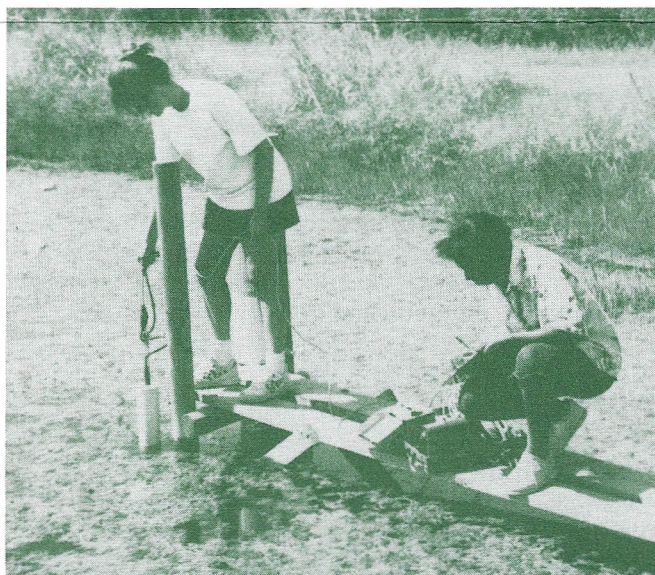


Eurasian watermilfoil (*Myriophyllum spicatum*). The native monoculture was the floating-leaved species American pondweed (*Potamogeton nodosus*), and the mixed native plant community included American pondweed, southern naiad (*Najas guadalupensis*), coontail (*Ceratophyllum demersum*), and muskgrass (*Chara vulgaris*).

The surface area of each study pond was approximately 0.75 acre (3,000 square meters), with an average depth of approximately 1 meter. The ponds are supplied with water from Lewisville Lake, an adjacent Corps of Engineers reservoir. The ponds can be filled and drained independently, allowing for control of the hydrologic regime. Each study pond contained a pier to provide access to the deepest portion of the pond, which facilitated sampling and observation. The piers were located away from the inlet/outlet structure to minimize the influence of incoming water. Each pond was also equipped with a permanent staff gauge for recording water levels.

Sampling

Ponds were monitored once every 2 weeks (bi-weekly), at approximately the same time of day each trip, beginning in March 1991 and ending in December 1992. Temperature and DO of the surface waters were measured in situ during each sampling trip using a calibrated Hydrolab Surveyor II.



Hydrolab surveyor being used to measure temperature, pH, DO, and conductivity

In addition to the routine biweekly monitoring, temperature and DO were monitored on a semicontinuous basis during the summer months of 1991 and 1992. This monitoring was accomplished with calibrated Hydrolab datasondes. The datasondes were anchored at the end of the piers, approximately 5 meters

from the shoreline, and were positioned so that the sensors were approximately 20 centimeters below the surface of the water. Data were logged hourly for 1-week intervals throughout the growing season. Only datasonde data for the period May through October 1991 and 1992 were used.



Datasonde being deployed in a pond. (Datasonde will measure and store hourly values for temperature and dissolved oxygen for 1 week before recalibration)

Data analysis was performed using parametric analysis of variance and nonparametric Kruskal-Wallis statistical tests. The statistics were computed for the minimum, maximum, average, and range for each 24-hour day of recorded information for each pond type, and on biweekly data from routine chemical monitoring.

Results and discussion

Averaged over the growing season, surface (20-centimeter depth) water temperature did not differ among the ponds. The growing season mean daily average temperature of the ponds was approximately 25 °C (Figure 1). During the winter months, essentially no differences in temperatures occurred among the ponds. However, during the summer months, as plant canopies developed, the ponds began to show differences in temperatures. During the period from mid-June to the end of August 1992, the native mixed pond, which did not develop a surface canopy, had the highest temperatures (Figure 2). The pondweed and waterhyacinth ponds, both of which developed extensive canopies of leaves at the water surface, exhibited temperatures that were cooler than the other

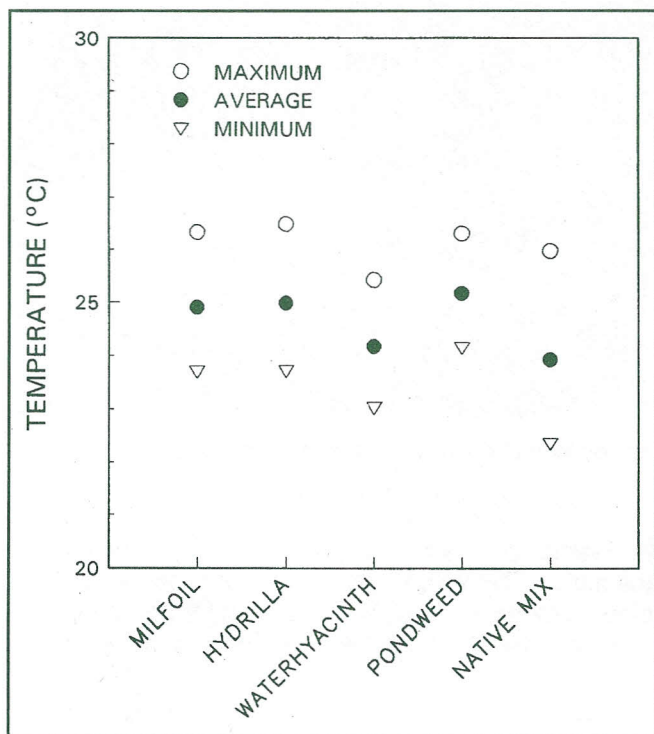


Figure 1. Mean daily maximum, daily average, and daily minimum temperatures of the five experimental ponds for May - October 1991 and 1992

ponds. This was evident during the summer months of both 1991 and 1992.

Because of their shallow depth and frequent mixing by wind, the LAERF ponds' temperatures tended to track average air temperatures fairly closely (Smart, Snow, and Dick 1992). In larger water bodies in which water temperatures lag behind average daily temperatures, vegetation may more profoundly alter water temperature by reducing water mixing and allowing warming of surface water (Juguet and Rostan 1973, Seki, Takahashi, and Ichimura 1979). Both floating-leaved (Juguet and Rostan 1979) and submersed species (Dale and Gillespie 1977) can create significant temperature gradients in which surface water is warmed several degrees above open-water temperatures. Bottom water temperatures change little over the day (Dale and Gillespie 1977).

Mean daily DO concentrations in the hydrilla and waterhyacinth ponds were significantly lower than in the other ponds (Figure 3). Dissolved oxygen concentrations were highest in the native community pond. Mean daily average DO levels in the waterhyacinth pond were below 5 milligrams per liter, which is undesirable for warmwater fisheries (Boyd 1979). Mean daily minimum DO concentrations in all but the mixed native community pond were also below the 5-milligram per liter DO stress level. Dissolved oxygen

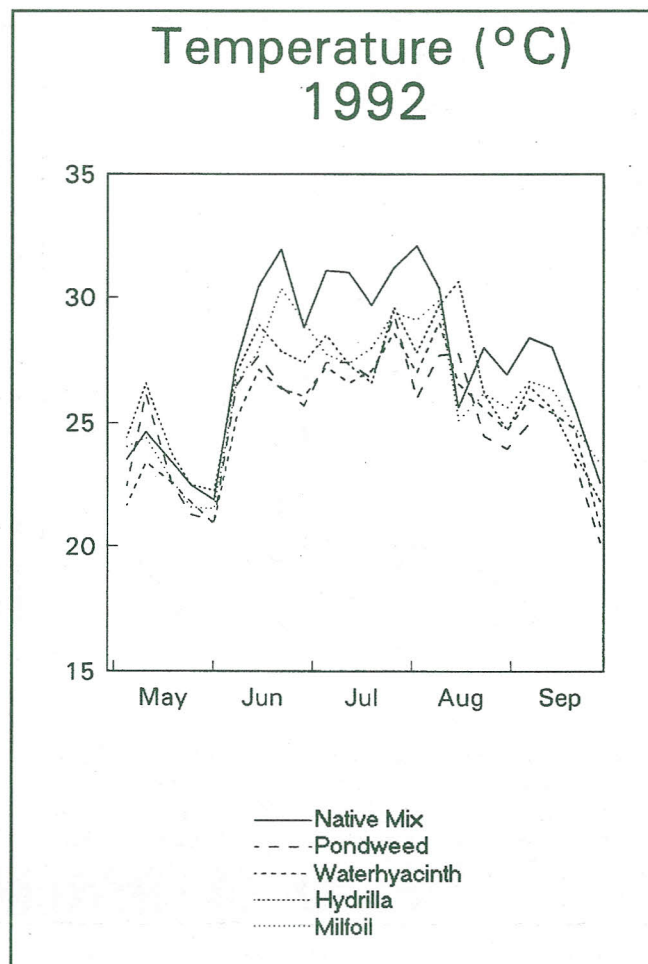


Figure 2. Temperature data for May-September 1992 obtained from biweekly monitoring of each of the five experimental ponds

levels in the ponds appear to be related to the surface area covered by the vegetation. Extensive surface coverage restricts the exchange of oxygen across the air-water interface, resulting in levels below saturation (Figure 3).

A substantial population of any canopy-forming species, exotic or native, could lead to critically low levels of dissolved oxygen, especially in the early morning period. More severe problems associated with extensive aquatic plant populations can also occur during senescence and decomposition, when DO concentrations may decline to near zero.

Dense mats of floating and submersed plants have been observed to deplete oxygen, particularly at night. During the daytime, large gradients in oxygen concentration may also be observed in submersed plant populations, with high concentrations in the upper layers and low concentrations in underlying, shaded portions (Buscemi 1958, Frodge, Thomas, and Pauley 1990). The floating plant waterhyacinth restricts gas exchange the most (Reddy 1985), followed by hydrilla,

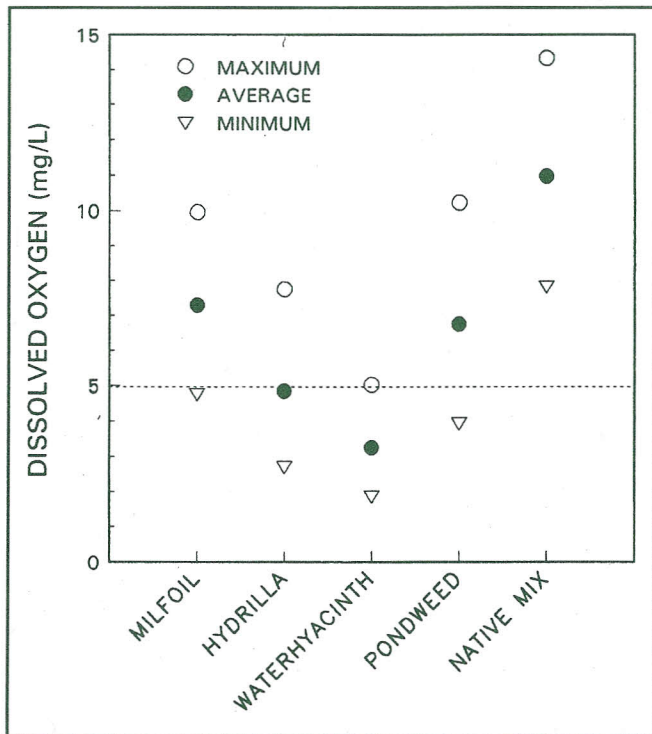


Figure 3. Mean daily maximum, daily average, and daily minimum dissolved oxygen of the five experimental ponds for May-October 1991 and 1992. The dotted line represents the 5-milligram per liter DO stress level for warmwater fisheries



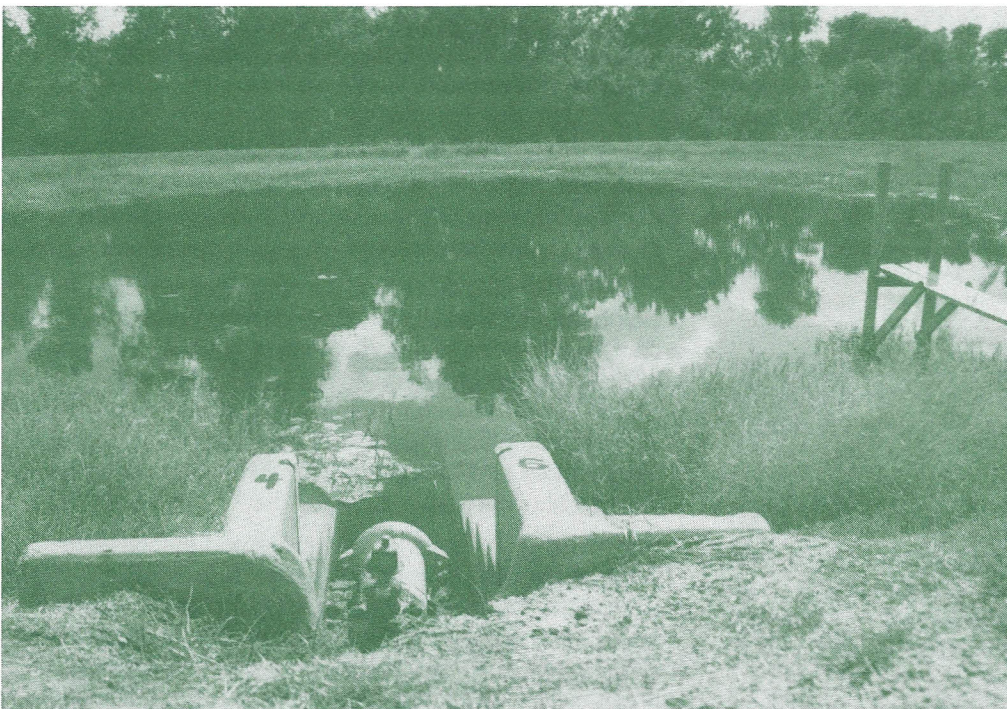
Canopy formation by waterhyacinth in a study pond

pondweed, and watermilfoil, all of which formed surface mats. The mixed native community did not develop an extensive surface canopy and thus did not restrict the entry of atmospheric oxygen into the water.

Conclusions

Based on a preliminary analysis of the results of a larger investigation, dissolved oxygen is the parameter most significantly affected by the different types of plant communities. The primary influence of plant type on dissolved oxygen is associated with canopy formation. Oxygen depletion beneath plant canopies

is likely due to the physical barrier that floating plants or leaves provide between the atmosphere and the water (Figure 4). This barrier reduces wind-driven water movement and impedes reaeration. In free-floating species, such as waterhyacinth, or floating-leaved species, such as American pondweed, photosynthesis contributes little oxygen to the water because gas exchange occurs between aerial leaves and the atmosphere, bypassing the water column. Decomposition of decaying plant material also exerts an oxygen demand, further reducing ambient oxygen concentrations.



A native species study pond, showing the distinct absence of a canopy formation

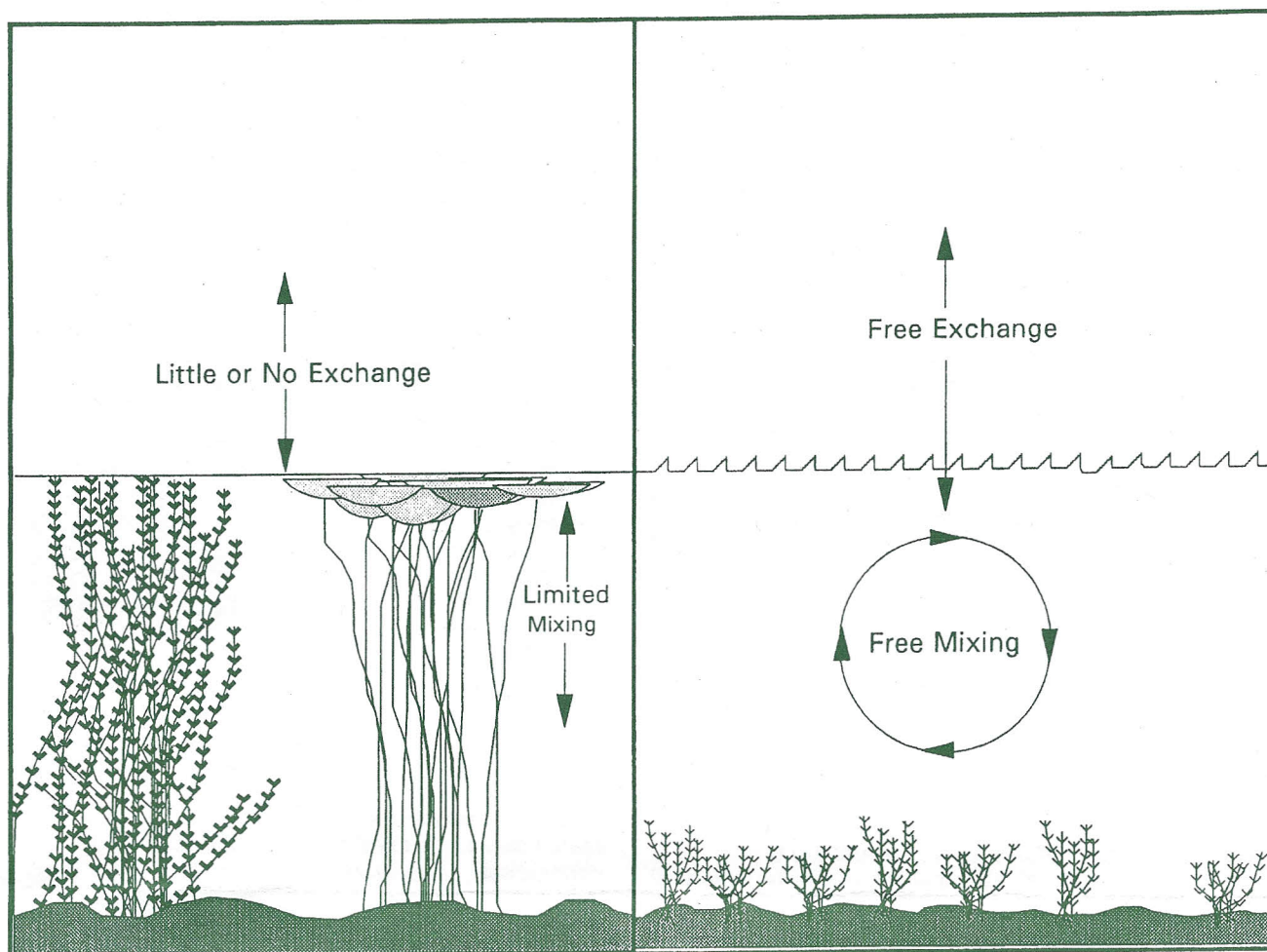


Figure 4. Diagram of the effect of plant canopies of emergent, floating, or submersed species in reducing free mixing and exchange (left) and reaeration in the absence of canopy formation (right)

All aquatic plants exert certain influences on the aquatic environment by reducing water flows, changing flow patterns, increasing sedimentation, and altering chemical composition of the water. Massive populations of any aquatic plant species, exotic or native, may cause diminished water quality and lowered oxygen availability. However, many exotic problem species often cause seriously degraded water quality and depleted DO levels. These exotics are often associated with water quality problems because their monoculture populations usually cover large expanses and also because they develop extensive canopies at the water surface. Both of these traits contribute to degraded water quality conditions.

In this study, the native species American pondweed also caused lowered DO levels. This species forms a surface canopy of floating leaves, and therefore can cause water quality problems similar to those associated with exotic species. While in this study pondweed covered much of the surface of the small pond,

this species rarely forms extensive monospecific populations in larger bodies of water. Thus, it is unlikely that American pondweed causes significant water quality problems in most aquatic systems.

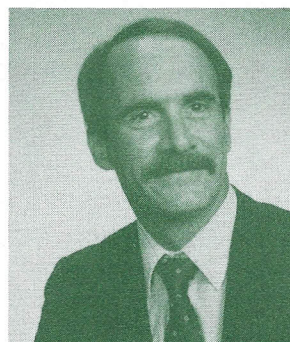
Aquatic plants are an important component of the aquatic ecosystem because they are the key interfaces between sediment, the water column, and the atmosphere in stream and lake ecosystems, controlling both productivity and biogeochemical cycles as well as structuring aquatic habitats (Carpenter and Lodge 1986). Although they are restricted in their distribution by their aquatic environment, aquatic plants in turn modify this environment by direct biological, chemical, and physical processes.

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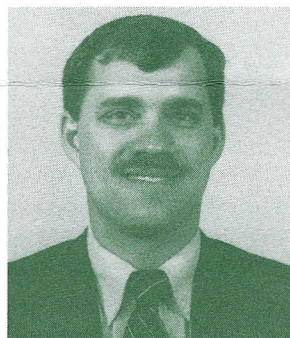
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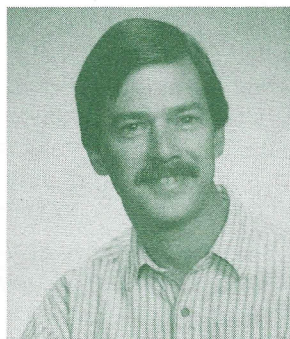
Mr. David R. Honnell, a scientist for AScl Corporation of McLean, Virginia, is stationed at the Lewisville Aquatic Ecosystem Research Facility (LAERF) in Lewisville, Texas. He oversees the operations of the analytical laboratory, which performs physical and chemical analyses on water, plant, and sediment samples. Mr. Honnell holds Bachelor of Science and Master of Science degrees in biology from Henderson State University.



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Dr. R. Michael Smart, an ecologist in the Environmental Laboratory, WES, is stationed at LAERF, where he is team leader. He conducts research on competition between aquatic plants, as well as their ecology and management. Dr. Smart has a Bachelor of Science degree in biology from the University of Southern Mississippi and a Doctor of Philosophy degree in marine biology from the University of Delaware.



Center for Aquatic Plant Research and Technology

In August 1993, the Corps of Engineers established a Center for Aquatic Plant Research and Technology (CAPRT) at the Waterways Experiment Station (WES) in Vicksburg, MS. J. L. Decell has been appointed as Director, CAPRT, in addition to his current position as Manager, Environmental Resources Research and Assistance Programs.

The CAPRT will provide a single element for coordination and facilitation at WES for all aquatic plant research and technology transfer to

- Congressmen and their staffs.
- Army staff.
- Corps Headquarters.
- Corps divisions, districts, and field operating elements.
- Installation Commanders and other Department of Defense users.
- Other Federal agencies.
- State agencies, academia, and private industry.

The CAPRT will address Federal-wide aquatic plant research and technology coordination needs for both civil and military programs. The CAPRT will also provide administrative and technological leadership, facilitation, and coordination of aquatic plant research and

technology development conducted under the auspices of the Corps' Aquatic Plant Control Research Program. Activities will include but are not limited to

- Technical assistance.
- Direct-allotted research and development.
- Technology transfer.
- Workshops and seminars.
- Work for others.
- Technical guidance documents.
- General information requests.
- Coordination with special interest groups and organizations.

In January 1994, the Director of the CAPRT will invite other Federal agencies to hold membership in the CAPRT and to collectively serve as a guidance committee that will set the future directions for the Center. It is intended that the CAPRT will provide some clearinghouse services to the overall science of aquatic plant management that either are not or cannot be facilitated by current Federal programs because of mission objectives. Once the guidance committee is formed and has initiated the task of identifying functional activities, a more detailed Information Bulletin will be published during fiscal year 1994.

Calendar of events

February 14-18, 1994

Corps of Engineers Seminar on Water Quality, Radisson Plaza Hotel, Savannah, GA, POC: Tom Patin, (601) 634-3444

March 7-9, 1994

Grass Carp Symposium, J. W. Reitz Union, University of Florida, Gainesville, FL, POC: Bobbi Goodwin, (904) 932-9613; (901) 392-3462 (FAX)

March 28 - April 1, 1994

Corps of Engineers Reservoir Shoreline Erosion/Revegetation Workshop, Denton, TX, POC: John Tingle, (601) 634-4227



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This issue reports on a study of the effect of aquatic plants on water quality. Aquatic plant species differ in their effects on water quality based on both physical structure and active uptake or excretion. Findings from these studies have implications for managing the desired quality of aquatic habitats for fisheries and recreation.



AQUATIC PLANT CONTROL RESEARCH PROGRAM

This bulletin is published in accordance with AR 25-30 as one of the information dissemination functions of the Environmental Laboratory of the Waterways Experiment Station. It is principally intended to be a forum whereby information pertaining to and resulting from the Corps of Engineers' nationwide Aquatic Plant Control Research Program (APCRP) can be rapidly and widely disseminated to Corps District and Division offices and other Federal and State agencies, universities, research institutes, corporations, and individuals. Contributions are solicited, but should be relevant to the management of aquatic plants, providing tools and techniques for the control of problem aquatic plant infestations in the Nation's waterways. These management methods must be effective, economical, and environmentally compatible. The contents of this bulletin are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such products. This bulletin will be issued on an irregular basis as dictated by the quantity and importance of information to be disseminated. Communications are welcomed and should be addressed to the Environmental Laboratory, ATTN: J.L. Decell, US Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, or call AC 601/634-3494.

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